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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Before The Board of Appeals & Interferences

In re Application of:
JAMES R. KAHN et al.
Serial No. 09/766,069
Filed: January 19, 2001
For: APPARATUS FOR SPUTTER DEPOSITION

Group Art Unit: 1745

Examiner: J. A. Mercado

Attorney Docket No. 353-05

Appeal No._______

Hon. Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

BRIEF ON APPEAL

This brief is being submitted in support of appeal filed May 19, 2003. This brief is submitted in triplicate.

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I. REAL PARTY IN INTEREST

The real parties in interest are Kaufman and Robinson, Inc. and Veeco Instruments Inc., as assignees of the named applicants.

II. RELATED APPEALS & INTERFERENCES

A related appeal is Appeal No. 2002-1148, decided April 25, 2003, in connection with parent application Serial No. 09/471,662, in which the rejection of apparatus claims was affirmed and the rejection of the method claim was reversed.

III. STATUS OF CLAIMS

Claims 1-17, inclusive, are pending in this application. All claims have been rejected. They are the subject of this appeal.

IV. STATUS OF AMENDMENTS

No amendments have been filed subsequent to the final rejection of the claims.

V. SUMMARY OF THE INVENTION

The invention pertains to sputtering of material from a sputter target onto a deposition substrate in an evacuated volume using an ion source from which the ions leave in the form of an ion efflux having an energy of about 50 eV or less. The sputter target is biased negative relative to ground. The ionizable gas within the evacuated volume is at a first pressure and the ionizable gas within the ion source is at a

second pressure. The first pressure is substantially less than the second pressure.

This combination of features provides advantages over conventional sputter deposition apparatus. In conventional ion beam sputtering, the ion beam is directed at a target with sufficient ion energy to sputter the target and deposit the sputtered material elsewhere on a substrate. To avoid contamination which would result from the ion beam striking and sputtering other hardware in the vacuum chamber, or the vacuum chamber itself, the ion beam must be directed only at the target. Restricting the ion beam to only the target is difficult and only partially successful, whether it is achieved by focusing or directing an ion beam that is inherently poorly defined at the beam edges, or defined by an aperture through which the beam passes and also sputters.

In one aspect of this invention, the sputter target surface is curved so as to either focus secondary electrons (when the target surface is concave) or defocus secondary electrons (when the target surface is convex). Optionally, a magnetic field may be provided near the sputter target to contain secondary electrons.

In another aspect of this invention, a method is provided for sputtering material from a sputter target onto a deposition substrate in an evacuated volume whereby secondary electrons are accelerated away from the target to form a beam of electrons which strike the deposition substrate.

In yet another aspect of this invention, a method is provided for sputtering material from a sputter target onto a deposition substrate in an evacuated volume whereby the deposition substrate is positioned outside the beam of secondary electrons.

In still another aspect of this invention, a method is provided for sputtering material from a sputter target onto a deposition substrate, wherein the magnitude of the ion efflux from the ion source and the magnitude of the bias of the sputter target are adjusted to assure unstable operation of the secondary electron beam.

In a further aspect of this invention, a method is provided for sputtering material from a sputter target onto a deposition substrate in an evacuated volume, wherein a magnetic field region is provided near the sputter target for containing secondary electrons.

The present invention differs sharply from conventional ion beam sputtering in that the beam is at a sufficiently low energy (50 eV or less) so that it can strike other hardware in the vacuum chamber, or the vacuum chamber itself, without causing significant sputtering. Further, the ion energy necessary for sputtering the target in the present invention is supplied primarily by biasing the target to a negative potential relative to the surrounding vacuum chamber.

VI. ISSUES

A. Whether claims 1-3, 9 and 14-16 have been properly rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 4,376,688 (Ceasar et al.) in view of U.S. Patent No. 5,914,018 (Fu et al.) and U.S. Patent No. 4,108,751 (King).

B. Whether claims 4, 5 and 17 have been properly rejected under 35 U.S.C. 103(a) as being unpatentable over Ceasar et al. in view of Fu et al., King and Pinarbasi (U.S. Patent No. 5,492,605).

C. Whether claims 6, 7 and 13 have been properly rejected under 35 U.S.C. 103(a) as being unpatentable over Ceasar et al. in view of Fu et al., King and Quazi (U.S. Patent No. 4,693,805).

D. Whether claim 8 has been properly rejected under 35 U.S.C. 103(a) as being unpatentable over Ceasar et al. in view of Fu et al., King and Arnold (U.S. Patent No. 5,423,971).

E. Whether claims 10-12 have been properly rejected under 35 U.S.C. 103(a) as being unpatentable over Ceasar et al. in view of Fu et al., King and the article entitled *Ion Beam Neutralization*.

VII. GROUPING OF CLAIMS

A. Claim 1 is an independent claim directed to sputtering apparatus for use in an evacuated volume comprising an ion source means for producing an ion efflux having an energy of about 50 eV or less, a sputter target which is biased negative relative to ground, and a deposition

substrate. The sputter target has a curved target surface. The ionizable gas within the evacuated volume is substantially less than the pressure within the ion source. This claim should be considered separately.

B. Claim 2 is a dependent claim directed to the apparatus of claim 1 and further recites that the curved sputter target surface is concave.

C. Claim 3 is a dependent claim directed to the apparatus of claim 1 and further recites that the curved sputter target surface is convex. This claim should be considered separately.

D. Claim 4 is dependent from claim 1 and further comprises a magnetic field near the sputter target to contain secondary electrons. This claim should be considered separately.

E. Claim 5 is an independent claim directed to sputtering apparatus for use in an evacuated volume comprising ion source means for producing an ion efflux having an energy of about 50 eV or less, a sputter target biased negative relative to ground, a deposition substrate, and a magnetic field near the sputter target to contain secondary electrons generated by the ion efflux striking the target. This claim should be considered separately.

F. Claim 6 is dependent from claims 1, 4 or 5 and recites that the target is biased by means of a radiofrequency bias.

G. Claim 7 is dependent from claims 1, 4 or 5 and recites that the target is biased by means of a pulsed bias.

H. Claim 8 is dependent from claims 1, 4 or 5 and further recites that the target is enclosed by an enclosure which defines the portion of the target that is exposed for sputtering.

I. Claim 9 is a dependent claim directed to the sputtering apparatus of claims 1, 4 or 5 and further recites that an additional reactive gas is introduced into the evacuated volume to promote the formation of compounds incorporating the reactive gas and material sputtered from the target. This claim should be considered separately.

J. Claim 10 is a dependent claim directed to the apparatus of claims 1, 4 or 5 and further recites that the ion source comprises a gridless ion source.

K. Claim 11 is a dependent claim directed to the apparatus of claim 10 and further recites that the gridless ion source includes an electron-emitting cathode which is biased negative of ground.

L. Claim 12 is dependent from claims 1, 4 or 5 and further recites that the ion source comprises a hollow cathode.

M. Claims 13 is dependent from claims 1, 4 or 5 and further recites that the operation of the ion source includes pulsed operation.

N. Claim 14 is an independent claim directed to the method for sputtering material from a target onto a deposition substrate in an evacuated volume. The method includes the steps of providing an ion source means for producing an ion efflux in which the ions have an energy of about 50 eV or less, providing a sputter target which is biased negative relative to ground, disposing the sputter target in the ion efflux of the ion source means, whereby material is sputtered from the sputter target and whereby secondary electrons generated from collisions of the ion efflux with the sputter target are accelerated away from the target to form a beam of electrons, positioning a deposition substrate in operative relation to the sputter target and the beam of electrons whereby material sputtered from the sputter target is deposited onto the substrate and the beam of electrons strikes the substrate. The pressure of the gas within the evacuated volume is controlled such that the pressure is substantially less than the pressure of the gas within the source. This claim should be considered separately.

O. Claim 15 is an independent claim directed to a method for sputtering material onto a deposition substrate in an evacuated volume. This method is similar to the method of claim 14 except that the deposition substrate is positioned in operative relation to the sputter

target outside the beam of electrons. This claim should be considered separately.

P. Claim 16 is an independent claim directed to a method for sputtering material onto a deposition substrate in an evacuated volume. The method is similar to the method of claim 14 except that the magnitude of the ion efflux and the magnitude of the bias of the sputter target are adjusted to assure unstable operation of the electron beam. This claim should be considered separately.

Q. Claim 17 is an independent claim directed to a method for sputtering material onto a deposition substrate in an evacuated volume. This method is similar to the method of claim 14 but further specifies that a magnetic field region is provided near the sputter target for containing the secondary electrons.

VIII. ARGUMENT

A. The Ceasar et al. Reference Does Not Describe An Ion Source Producing Ions of 50 eV or Less

The primary reference, Ceasar et al., describes an ion source of the type designed by one of the present applicants, Harold R. Kaufman. In his Declaration dated November 25, 2002, Harold R. Kaufman explained that he is the inventor of the ion source described in U.S. Patent No. 3,156,090. The only ion source referred to by Ceasar et al. is a Kaufman source. Dr. Kaufman has intimate knowledge of such ion source and its manner of operation. In the aforementioned Declaration, Dr.

Kaufman carefully explained that neither of the ion sources described in the Ceasar et al. patent, operated in the manner described by Ceasar et al., would be capable of operating at ion beam energies of 50 eV or less. Further, the Kaufman Declaration explained that sputtering using the ion source he invented (and Ceasar et al. used) is impossible at an ion beam energy at 50 eV or less unless the target has a negative bias, and the examiner has not provided any evidence or reasoning to the contrary. Also, the gridded Kaufman ion source is described by Harper (*Thin Film Processes*-Chapter 5, *Ion Beam Deposition)*, as producing an ion energy range of 500 to 2000 eV.

Thus, the primary reference, Ceasar et al., does not describe use of an ion source which emits ions having an energy of 50 eV or less. This feature is critical to applicants' invention, and Ceasar et al. fail to describe or suggest it.

B. Fu et al. Patent Does Not Pertain To An Ion Beam Source

The teachings of the Fu et al. patent relate to a direct-current diode, without an ion source operating at a pressure substantially higher than the surrounding volume, and it does not produce an ion beam directed at the target. Although the Fu et al. patent does mention a negative bias, a direct-current diode requires a negative bias in order to work.

The Kaufman Declaration explains that the Fu et al. patent refers to a fundamentally different art than sputtering by directed ion beams. Also, the purpose of a shape for the target

surface in Fu et al. is to eliminate re-deposition on the target sidewall (col. 2, lines 62-64), whereas in the present invention the shaping is for the purpose of controlling the trajectories of the secondary electrons that are emitted from the target surface (see p. 17, lines 1-13, of applicants' specification). A concave shape of the target surface results in a focused shape for the beam of secondary electrons; a convex shape of the target surface results in an expanding or defocused shape for the beam of secondary electrons.

C. The King Reference Does Not Cure The Deficiencies of Ceasar et al. and Fu et al.

The King reference also fails to describe use of an ion source producing ions of 50 eV or less. The King reference mentions the duoplasmatron of von Ardenne and the Kaufman ion source. The operation of either of those described sources would not produce ion energies of 50 eV or less. In col. 5, lines 31-37, King recites the useful energy range for the ions as "0.5-50 keV". Although King mentioned at col. 4, lines 58-60, that a threshold sputtering energy may be 20-30 eV, he goes on to say "but removal of significant amount of surface material (i.e. yields approaching 1 atom/ion) are not usually achieved until incoming energies are in the order of 100's of eV". Further, King is referring to deposition on substrate 5, not sputtering from target 4, in lines 58-60. The entire paragraph beginning at Col. 4, line 53, refers to the energy of the depositing atoms or molecules onto the substrate.

Thus, the King reference teaches one of ordinary skill in the field that there is no practical operation at an ion beam energy in the 50 eV range. At col. 5, lines 31-34, King describes the energetic ion beam as having an energy of 0.5 to 50 keV, usually greater than or equal to 20 keV.

Furthermore, King does not teach the use of a negatively biased target. Of primary concern to King is that the ions intercept the target, which is consistent only with ions at energies above the sputtering threshold.

Consequently, the teachings of King do not cure the deficiencies of the Ceasar et al. and Fu et al. references. Even if the teachings of those references are combined, that would not lead to the sputtering apparatus of applicants' claims 1-3 or 9, nor would it lead to the methods of applicants' claims 14-16.

Each of applicants' apparatus claims 1-3 requires (a) the ions in the ion efflux to have an energy of about 50 eV or less, (b) the sputter target to have a curved surface and to be biased negative relative to ground, and (c) the pressure of the ionizable gas within the evacuated volume to be substantially less than the pressure within the ion source. None of the cited references describes this combination of features. The combination of the teachings of the cited references also fails to suggest the combination of features as claimed by applicants.

Applicants' claim 9 requires (a) the ions in the ion efflux to have an energy of about 50 eV or less, (b) the sputter target to be biased negative relative to ground, (c) a magnetic field to be located near the sputter target for containing secondary electrons, (d) the pressure of the ionizable gas within the evacuated volume to be substantially less than the pressure within the ion source, and (e) an additional reactive gas is introduced into the evacuated volume to promote the formation of compounds incorporating both the reactive gas and the material sputtered from the sputter target.

The cited references, whether considered alone or in combination, fail to describe or suggest applicants' claimed combination of features.

Applicants' claim 14 is a method for sputtering material in an evacuated volume and requires (a) providing an ion source wherein ions leaving the ion source are in the form of an ion efflux having an ion energy of about 50 eV or less, (b) biasing the sputter target negative relative to ground and disposing the sputter target in the ion efflux, whereby material is sputtered from the sputter target and secondary electrons generated from collision of the ion efflux with the sputter target are accelerated away from the sputter target, (c) positioning the deposition substrate in operative relation to the sputter target and the beam of secondary electrons such that sputtered material is deposited on the substrate and the

secondary electrons strike the substrate, and (d) controlling the pressure of the gas within the volume such that the pressure is substantially less than the pressure of the gas within the ion source.

Applicants' claim 15 is a method for sputtering material similar to claim 14, except that the deposition substrate is positioned outside the beam of secondary electrons.

Applicants' claim 16 is a method for sputtering material similar to claim 14, except that the magnitude of the ion efflux from the ion source means and the magnitude of the bias of the sputter target are adjusted to assure unstable operation of the secondary electron beam.

The cited references do not describe or suggest the methods of applicants' claims 14-16. The Kaufman Declaration explains that the only ion source mentioned by Ceasar et al. is a Kaufman source (col. 5, lines 43 and 47) which was designed by Kaufman himself (one of the present inventors). Kaufman also explained that he has tested the type of ion source described by Ceasar et al. and states that such source could not have generated an ion beam of 50 eV or less. Further, the Kaufman Declaration explained that sputtering using the ion source he invented (and Ceasar et al. used) is impossible at an ion beam energy at 50 eV or less unless the target has a negative bias, and the examiner has not provided any evidence or reasoning to the contrary.

Further, the King reference teaches the use of an ion beam energy of 500-50,000 eV. The Fu et al. reference does not pertain to ion beam sources. Rather, it relates to a direct-current diode, and it does not produce an ion beam directed at the target. Consequently, the combination of the teachings of these references would not lead to applicants' claimed methods.

D. Pinarbasi Does Not Teach Containment of Secondary Electrons

The Pinarbasi patent discloses a sputtering apparatus in which a magnetic field may be used to prevent electrons from the cathode from traveling directly to the anode. The patent does not, however, teach the use of a magnetic field near the sputter target for containing secondary electrons generated by the ion efflux striking the sputter target, as required in applicants' claims 4, 5 and 17.

E. The Quazi Reference Does Not Teach Low Energy Ion Source

The Quazi reference merely refers to the use of an rf bias but does not teach or suggest operation with a low energy ion source. Consequently, combination of Quazi with Ceasar et al, Fu et al. and King would not suggest applicants' claimed invention. Applicants' claims 6, 7 and 13 are dependent from claims 1, 4 or 5 and require the combination of several features, including (a) low energy ions, (b) negatively biased sputter target, and (c) substantially lower gas pressure in the evacuated volume than within the ion source. The primary

references do not teach or suggest this combination of features.

Quazi refers to a radiofrequency bias in a RF glow discharge. The patent does not teach anything regarding a low energy directed ion beam. Further, Quazi requires much higher gas pressure than is used in the present invention.

Consequently, the combination of Quazi with the other three cited references would not lead to applicants' claimed combination.

F. <u>The Arnold et al. Reference Does Not Teach Use of a Low Energy Source</u>

Although the Arnold et al. reference shows use of a "dark space shield" in "cathode sputtering", it does not teach the use of a low energy ion source. Consequently, it does not cure the deficiencies of the other cited references as explained above.

Therefore, the combination of Arnold et al. with the other references would not lead to the subject of applicants' claim 8 which requires use of a low energy source, along with the other features recited in claims 1, 4 or 5.

G. <u>The *Ion Beam Neutralization* Article Does Not Cure the Deficiencies of the Other Cited References</u>

The *Ion Beam Neutralization* article describes an end-Hall type of gridless source and a hollow cathode source. Such

teaching would not suggest use of an end-Hall ion source in the Ceasar et al. apparatus.

The Ceasar et al. patent describes the need to confine almost all of the ion beam by focusing it onto the target. Neither the end-Hall type of gridless source nor the hollow cathode source would satisfy the requirement of Ceasar et al. for an ion beam that is confined to the target.

Consequently, the cited article, by merely describing ion sources, does not provide any teaching which would lead to the invention of applicants' claims. Combination of the cited article with Ceasar et al., Fu et al. and King still would not suggest the combination of features claimed herein.

H. Conclusion

The cited references considered in combination would not lead to the invention as claimed in applicants' claims in this application. Thus, the Section 103(a) rejections of the claims are unsound and should be reversed.

Respectfully submitted,

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DEAN P. EDMUNDSON, REG. NO. 25,723

SIGNED Dean P. Edmundson

DATE 7-3-03

APPENDIX

The Rejected Claims

1. A sputtering apparatus for use in an evacuated volume comprising:

ion source means for ionizing an ionizable gas to produce a plasma, wherein ions leaving said ion source means are in the form of an ion efflux having an energy of about 50 eV or less;

a sputter target, biased negative relative to ground, and having a curved target surface, wherein said curved target surface is disposed in the ion efflux of said ion source means, whereby particles of material are sputtered from said target;

a deposition substrate upon which the material sputtered from said sputter target is deposited;

and wherein said ionizable gas within said evacuated volume is at a first pressure and said ionizable gas within said ion source is at a second pressure, and wherein said first pressure is substantially less than said second pressure.

2. A sputtering apparatus in accordance with claim 1, wherein said curved target surface is concave.

3. A sputtering apparatus in accordance with claim 1, wherein said curved target surface is convex.

4. A sputtering apparatus in accordance with claim 1, further comprising a magnetic field located near said sputter target and having sufficient strength and thickness to contain secondary electrons generated by said ion efflux striking said sputter target.

5. A sputtering apparatus for use in an evacuated volume comprising:

ion source means for ionizing an ionizable gas to produce a plasma, wherein ions leaving said ion source means are in the form of an ion efflux having an energy of about 50 eV or less;

a sputter target, biased negative relative to ground, with said target disposed in the ion efflux of said ion source means, whereby particles of the material are sputtered from said sputter target;

a deposition substrate upon which the material sputtered from said sputter target is deposited;

a magnetic field located near said sputter target of sufficient strength and thickness to contain secondary electrons generated by said ion efflux striking said sputter target.

and wherein said ionizable gas within said evacuated volume is at a first pressure and said ionizable gas within said ion source means is at a second pressure, and wherein said first pressure is substantially less than said second pressure.

6. A sputtering apparatus as defined in claims 1, 4, or 5 in which said sputter target is biased by means of a radiofrequency bias and in which the negative bias is a mean value of the radiofrequency bias.

7. A sputtering apparatus as defined in claims 1, 4, or 5 in which the bias of said sputter target is a pulsed bias and in which the negative bias is a mean value of the pulsed bias.

8. A sputtering apparatus as defined in claims 1, 4, or 5 in which said sputter target is enclosed by a target

enclosure, where said target enclosure defines a portion of said sputter target that is exposed for sputtering.

9. A sputtering apparatus as defined in claims 1, 4, or 5 in which an additional reactive gas is introduced into said evacuated volume to promote the formation of compounds incorporating both said reactive gas and said material sputtered from said sputter target.

10. A sputtering apparatus as defined in claims 1, 4, or 5 in which said ion source comprises a gridless ion source.

11. A sputtering apparatus in accordance with claim 10, wherein said gridless ion source includes an electron-emitting cathode which is biased negative of ground to reduce the energy of the ions in said efflux.

12. A sputtering apparatus as defined in claims 1, 4, or 5 in which said ion source means comprises a hollow cathode.

13. A sputtering apparatus as defined in claims 1, 4, or 5 in which the operation of said ion source means includes pulsed operation.

14. A method for sputtering material from a sputter target onto a deposition substrate in an evacuated volume, the method comprising the steps of:

(a) providing an ion source means for ionizing an ionizable gas to produce a plasma, wherein ions leaving said ion source means are in the form of an ion efflux having an energy of about 50 eV or less;

(b) providing a sputter target;

(c) biasing said sputter target negative relative to ground and disposing said sputter target in the ion efflux of said ion source means, whereby material is sputtered from said sputter target and whereby secondary electrons generated from collision of said ion efflux with said sputter target are accelerated away from said biased sputter target to form a beam of electrons;

(d) positioning a deposition substrate in operative relation to said sputter target and said beam of electrons, whereby said material sputtered from said sputter target is deposited onto said substrate and said beam of electrons strikes said substrate; and

(e) controlling the pressure of said gas within said volume such that said pressure is substantially less than the pressure of said gas within said ion source means.

15. A method for sputtering material from a sputter target onto a deposition substrate in an evacuated volume, the method comprising the steps of:

(a) providing an ion source means for ionizing an ionizable gas to produce a plasma, wherein ions leaving said ion source means are in the form of an ion efflux having an energy of about 50 eV or less;

(b) providing a sputter target;

(c) biasing said sputter target negative relative to ground and disposing said sputter target in the ion

efflux of said ion source means, whereby material is sputtered from said sputter target and whereby secondary electrons generated from collision of said ion efflux with said sputter target are accelerated away from said biased sputter target to form a beam of electrons;

(d) positioning a deposition substrate in operative relation to said sputter target, outside of said beam of electrons, whereby said material sputtered from said sputter target is deposited onto said substrate; and

(e) controlling the pressure of said gas within said volume such that said pressure is substantially less than the pressure of said gas within said ion source means.

16. A method for sputtering material from a sputter target onto a deposition substrate in an evacuated volume, the method comprising the steps of:

(a) providing an ion source means for ionizing an ionizable gas to produce a plasma, wherein ions leaving said ion source means are in the form of an ion efflux having an energy of about 50 eV or less;

(b) providing a sputter target;

(c) biasing said sputter target negative relative to ground and disposing said sputter target in the ion efflux of said ion source means, whereby material is sputtered from said sputter target and whereby

secondary electrons generated from collision of said ion efflux with said sputter target are accelerated away from said biased sputter target to form a beam of electrons;

(d) adjusting the magnitude of said ion efflux from said ion source means and the magnitude of said bias of said sputter target to assure unstable operation of said electron beam; and

(e) controlling the pressure of said gas within said volume such that said pressure is substantially less than the pressure of said gas within said ion source means.

17. A method for sputtering material from a sputter target onto a deposition substrate in an evacuated volume, the method comprising the steps of:

(a) providing an ion source means for ionizing an ionizable gas to produce a plasma, wherein ions leaving said ion source means are in the form of an ion efflux having an energy of about 50 eV or less;

(b) providing a sputter target;

(c) biasing said sputter target negative relative to ground and disposing said sputter target in the ion efflux of said ion source means, whereby material is sputtered from said sputter target and secondary electrons are generated by said ion efflux striking said sputter target;

(d) providing a magnetic field region near said sputter target for containing said secondary electrons;

(e) positioning a deposition substrate in operative relation to said sputter target whereby said material sputtered from said sputter target is deposited onto said substrate; and

(f) controlling the pressure of said gas within said volume such that said pressure is substantially less than the pressure of said gas within said ion source means.